INTERNATIONAL RICE COMMISSION

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METHODS USED IN MAKING AND TESTING A LARGE NUMBER OF RICE SELECTIONS IN THAILAND*

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IN areas where little or no plant improvement studies have been under way and a great amount of variation between plants in a field of common rice is found and where on observation it is evident that many of the varieties grown by the farmers are not pure, individual head or plant selection offers a useful method for improvement as to yield, quality, and other important characteristics. While hybridization is important, it often is not desirable to proceed at once with a hybridization program, especially in a new area, until more is learned about types and varieties of rice desirable for the the region. Seclection offers a quicker method of obtaining some new worthwhile sorts than does hybridization, due to the fact that in a hybridization program more generations need to be grown before new sorts can be produced and thoroughly tested than is the case when following the selection method.

Making Selections

When a selection program is to be undertaken it is important that one have facilities for dealing with large numbers of selections, due to the fact that, generally speaking, the type of plant cannot be changed by selection within the offspring of a single homozygous plant. This is due to the fact that rice

* *This project is handled jointly by Doctors Krui and Sala of the Department of Agriculture of the Ministry of Agriculture of Thailand and E.R. Brooks, J. R. Thysell and H. H. Love of STEM to Thailand.*

is largely self-fertilized. This means that the first selections are of great importance, and since from the standpoint of yield there is little to guide the plant breeder in making selections in the field other than to avoid weak and diseased plants, it is evident that the chances of obtaining some worthwhile lines are dependent on the amount of material with which the selection program is begun. This means that a large number of selections from various localities and of different types is of greatest importance. In making selections it is desirable to visit many fields in different localities and make individual head selections. If in a locality certain varieties are definitely recognized as being poor producers one might not want to make so many selections from such fields. However, it is possible to obtain some worthwhile selections even from fields sown from a poor variety. One of the outstanding varieties of oats obtained by H.H. Love, in New York State, following selection was made from an undesirable variety. When it is recognized that varieties growing in certain fields in each locality are considered to be better from the standpoint of yield, quality, and the like, it would be desirable to make a larger number of selections from such fields than from fields sown to a poor variety. It is important, however, that one obtain selections from all sorts of different types and from all sorts of conditions.

When making selections it is not desirable to make these selections merely along the edge of the field but one should go into the field, observing the different types, and obtain a large number of heads, making at least 150 or more selections from each field. One should avoid selecting heads from only the tallest plants. With one unused to making selections, this mistake is likely to occur. Where different types of rice, such as early, medium, or late, and glutinous and nonglutinous sorts are commonly grown, it is important to make selections from all these different kinds. The name of the variety, if it has a local name, the name of the farmer, village, and locality should be recorded on each lot of selections. One of the purposes for this is that should we find upon later testing that selections from a given locality prove to be more outstanding than the others, it would be possible to return to that same locality another season to make more selections. After the selections have been made the seed from each individual head should be put in a small envelope, carefully labeled, and then placed in a container that will keep the seed free from insects and rodents. One must make sure that the seed is perfectly dry before storing.

For the first large-scale selection program in Thailand, in 1950, selections were made from a total of 978 different fields in 35 localities. The total number of individual heads amounted to about 120,000. Due to some shattering, breakage of heads in shipping, and some other unavoidable losses, there was a total of over 114,000 of these grown in 1951.

The Plan for the First Year—1951

Before planting time the selections were grouped according to maturity and the like. Planting plans were made including such information as locality, where selections were made, and the field row number in which a selection was to be planted. The locality was given a number and then the different varieties selected from that locality were also given numbers followed by the number of each selection made from that variety. Thus 1-2-10 means that this is selection number ten from the second variety selected in locality one. Each selection on the plan for planting had a similar number. This system enabled us to keep careful records of each selection and to make comparisons between the selections made from one variety as well as to compare selections made from other varieties found in the same locality.

Since facilities for testing the selections in the field were not available at all the different localities where the selections were made, it was necessary to test them at the experiment stations where such facilities were available. The selections made in the Central Plain of Thailand, with the exception of the floating types, were divided and a number of them were grown at Bangkhen and the rest at Rangsit. The floating types were tested at the deep-water station at Hantra. The selections made from the north and northeast areas of Thailand were tested at two places, Mae Jo and San Patong near Chiengmai. The number of selections grown at the different stations follows:

Locality	*Number of Selections*
Bangkhen	20,124
Rangsit	45,356
Mae Jo	10,851
San Patong	13,089
Hantra (deep water)	24,659
Total	114,079

On some fields, particularly at Rangsit and in northern Thailand, it was possible to sow the seed directly in the field. Where this was not possible the seed of the selections had to be sown on seedbeds, keeping the seed from each selection separate. If direct seeding is followed a few seed from each selection should be placed at the end of the row and if transplanting is followed a few seedlings should be placed at the end of the row, to be used for replanting where necessary. It it not wise to put a large amount of seed, or a large number of seedlings, at the end of the row since this is likely to cause crowding and results in weak seedlings. If it is desirable to make certain of having plenty of plants for replanting, then some plants may be grown at each end of the row using care to avoid mixing. The rows were three meters long and one-third meter apart. (If conditions such as land and labor permit, longer rows may be used.) The seeds or plants were placed ten centimeters apart in the row. By having one plant in a place, differences in tillering may be easily observed, and if mixtures occur they may be easily detected. In order to have a guide as to soil variability and the performance of the new selections, check rows of a standard variety of approximately the same

maturity as the selections being tested were placed every tenth row in the field.

General notes and observations were made throughout the growing season and then as the plants were well headed and nearing maturity each selectian was observed carefully, comparing it with the adjacent selections and with the two nearest checks. With the planting plan followed there were nine selections between each pair of checks so one could compare the new selections with the performance of the nearest checks. The selections that seemed promising were marked by placing stakes at the end of the row as well as recording this on the planting plan. Some days after the first rows had been chosen and marked by stakes, the material was all studied again to see whether the ones selected from the earlier study still continued to look promising and to see whether some may have been missed the first time. The marked rows were harvested and no yield was taken this first year. It was felt that with only one short row the yield would not be too reliable. General observations on the way the selectiocs developed through the season were considered of more value as a guide for making selections to be continued the following year. The seed from the selected plants, after being carefully dried, was placed in small bags and stored in a safe place away from insects and rodents for use in 1952.

The Plan for the Second Year—1952

For the second year it was possible to make a more adequate test of each selection in that it was possible to replicate each selection in the field. Complete planting plans were made for all tests. The method followed was to have rows four meters long, one—third meter between rows, and a plant placed every ten centimeters. Checks were used every tenth row as was done the first year. One row each of all the different selections was placed in the field and then the entire series was repeated in the same field. In order to have more information as to the performance of these selections and as insurance against loss of the selections in one locality, a third replication was grown at a different station. For example, the selections which were made from the material grown at Bangkhen in 1951 were tested at Bangkhen in duplicate rows or plots in 1952 and the third replication was grown at Rangsit. The material selected from the 1951 crop at Rangsit was handled in a similar manner, having duplicated rows at Rangsit with a third replication grown at Bangkhen. In the north the selections made at Mae Jo and San Patong were handled in a similar manner. The method of grouping the selections according to maturity was followed the second year and direct planting or transplanting was used, depending upon the condition of the field. A new station, Kok Samrong, located in a region where early rice is grown, was added so that we might have a better place for comparing the early selections. The number of selections grown at the different stations in 1952 was as follows:

Locality	*Number of Selections*
Kok Samrong	1,350
Bangkhen	5,443
Rangsit	7,171
Hantra	3,122
Mae Jo	2,155
San Patong	3,312
Total	22,553

General notes and observations were taken throughout the growing season and the more promising rows were again marked with stakes as was done in 1951. Since we had more replications, yields were taken and these yields together with the selections chosen by field observation were used to determine what selections were to be continued for the third year. The yields of the selections were compared directly with the checks. From these data certain facts are outstanding. One of these is that certain varieties give very few or no good selections. It also appears that the selections made from certain localities are better than those made from others. Considerable variation in yield is shown by the different selections made from certain varieties when grown side by side in the field. The data presented in Table I will illustrate some of this variation.

TABLE I

YIELDS OF RICE SELECTIONS OBTAINED FROM THREE REPLICATIONS AT KOK SAMRONG IN 1952

Selecsion Number	*Average Checks*	*Yield Kg/Rai Selection*	*Gain or loss Kg/Rai compared with checks*	*Gain in Percent*
This Variety Furnished Promising Selections				
20 – 29 – 30	399	604	205	51.4
20 – 29 – 35	398	710	312	78.4
20 – 29 – 37	402	561	162	40.3
20 – 29 – 38	408	544	136	33.3
20 – 29 – 42	414	629	215	51.9
20 – 29 – 46	421	663	242	57.5
20 – 29 – 47	428	558	130	30.4
20 – 29 – 56	434	618	184	42.4
20 – 29 – 57	442	668	226	51.1
This Variety Furnished No Outstanding Selections				
4 – 1 – 119	540	517	31	5.7
4 – 1 – 120	537	603	66	12.3
4 – 1 – 121	540	550	10	1.9
4 – 1 – 125	549	573	24	4.4
4 – 1 – 126	553	478	– 75	– 13.6
4 – 1 – 128	555	515	– 40	– 7.2
4 – 1 – 130	557	472	– 85	– 15.3
4 – 1 – 133	558	479	– 79	– 14.2
4 – 1 – 135	561	541	– 20	– 3,6

The nine selections made from variety 29 and locality 20 all yield higher than the check variety. All of the selections seem worthy of further study. There is considerable variation between the yields of the several selections as is to be expected. Selection 20-29-47 yields lower than the selections growing adjacent to it, and other differences may be noted.

The selections made from variety one and locality four give very different results. No one selection is outstanding in yield and five of the nine actually yielded less than the check. These data illustrate the kind of results obtained when studying the yielding ability of a number of selections, and emphasize the importance of having a large number of selections from many different localities.

The Plan for the Third Year — 1953

The plan for field testing has been changed for this year. The material is grown in single rows four and one-half meters long and one-third meter apart and the hills are 25 centimeters apart in the row with three plants per hill. Five replications with checks located every tenth row have been planted except in some instances when there was a shortage of seedlings. With a large number of selections still remaining the arrangement of the varieties was not made at random for the different replications, since similar testing with rice and other crops has indicated that at this stage it is not necessary. Complete planting plans were made as usual.

The number of selections now growing at the different stations in 1953 is as follows:

Locality	*Number of Selections*
Kok Samrong	727
Bangkhen	2,197
Rangsit	2,612
Hantra	1,314
San Patong	3,212
Total	10,062

In addition to the general field notes the yields of each row will be taken and and the results will be compared with the checks, and the promising selections based on this information will be chosen for testing the fourth year.

For the fourth — year test, if we do not have too many selections remaining and facilities permit, we may change to three-row plots for each selection and use six replications in the field. If there is still a large number of selections remaining to be tested, it may be necessary to continue to use single rows but with a large number of replications and where possible test the selection in more than one locality. Random arrangement of the different sorts may be followed If not, then check plots will be placed every tenth plot as has been with the earlier tests. Transplanting will be used in all cases.

It may be added that, for best results, in a selection program it is not sufficient to depend upon one collection of material. If facilities permit it is worthwhile to make a new collection of heads every other year, or every third year. This makes it possible to have more selections from the areas formerly sampled as well as from new areas not visited previously. With this in mind, another large collection, about 90,000, was made in Thailand from the 1952 crop. These have been divided and most of them are being grown at five different stations the present season (1953).

BETTER YIELDS WITH FERTILIZERS

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Rice yields can be greatly increased in Thailand through fertilization. Even the most skeptical would surely come to this conclusion were he to examine the data obtained by the Department of Agriculture from the widely distributed experiments during the past three years. This does not mean that all the fertilization problems have heen solved, far from it, but it does appear that there is sufficient background information for initiating a large scale use of fertilizers. After all, farmers' experiences are also invaluable as supplements to the information secured through the more refined research.

Phosphorus is the Key: Response to phosphorus applications has been almost universal and generally very large. The use of other nutrients without phosphorus has been ineffective with practically no exceptions. With no phosphorus being supplied over a long period of time and apparently the high fixation capacity of most soils, it is hardly surprising that phosphorus gives a marked response. Furthermore, rice has a remarkable capacity for extracting phosphorus even in the less soluble forms.

At the Central Experimental Station at Bangkhen, the no treatment plots produced from 800 to 2,000 kg./hectare in several seasons. Phosphorus used alone gave an increase of 1,000 kg. to 2,500 kg. Adding nitrogen gave an additional increase, with a large amount of nitrogen (90 kg./N/hectare) increasing the yield to about 1,000 kg. when used with a small amount of phosphorus (25 kg./hectare). There has been an exceedingly interesting and perhaps very significant phenomenon of nitrogen inter-reaction with phosphorus, as nitrogen contributes very little to the yield when used with a maximum rate of phosphorus, but very much when used with a minimum rate of it.

Nitrogen used alone has given little or no increase in any of the several trials at Bangkhen.

The experiment at the Non Sung Field Station in the Northeast in 1952 will serve to illustrate the kind of response that was obtained in the out-lying field tests. While the response is marked in all the 30 places where the tests were conducted, the amonnt of increase varies widely between them.

At Non Sung the no treatment plots (4 replications) averaged 822 kg./ hectare. Nitrogen used alone (37.5 kg./N/hectare) depressed the yield by 25 %. Phosphorus applied at 37.5 kg./F_2O_5/hectare increased the yield to 1,567 kg./hectare. The combination of these two amounts of nitrogen and phosphorus produced 2,344 kg./hectare. Yields were further increased with a corresponding increase in the amounts of fertilizers used. 75 kg. each of N and P_2O_5 gave a yield of 3,178 kg./ hectare, or 3.9 times the check.

Rock Phosphate Gives Promise: An interesting experiment on the use of rock phosphate (tri-calcium phosphate) was started at Bangkhen in 1950, in comparison with ordinary 20% superphosphate. It was found that the lower rates of rock phosphate (25 and 75 kg./P_2O_5/ hectare) were not generally as productive as the corresponding rates of superphosphate. For the past three years, the highest rate of rock phosphate (125 kg./ P_2O_5/ hectare) gave a total increase of 2,104 kg./hectare, while the corresponding rate of superphosphate gave a total increase of 2,309 kg./hectare. But in 1952, the third year after the fertilizer application, the increase from these two kinds of phosphates was respectively 1,125 kg. and 1,045 kg. over the check.

The cost of phosphorus in the untreated or tri-calcium form is now and is likely to remain much lower than in either the mono-, or di-calcium form. At present the difference in quotations for Thailand delivery is very large. The above studies lend much support for the lower cost materials. The experiments also indicate that phosphorus need not be applied every year, as the residual effects remain available. It seems possible to use tri-calcium phosphate once every 2 to 4 years and nitrogen annually as ammonium sulfate or some other suitable nitrogen carrier. Such a method would go a long way towards lowering the cost and simplifying rice fertilization. More exhaustive experiments to compare the forms of phosphates, amounts and frequencies of application have been started this year.

Another experiment started last year at Bangkhen and in Southern Thailand seems to throw some light on phosphorus utilization. Superphosphate was used to supply 37.50, 56.25 and 75 kg./ P_2O_5/ hectare and applied in two ways: (a) mixed in well before transplanting, and (b) applying onto the surface immediately after transplanting. Nitrogen was applied uniformly at a moderate rate. At Bangkhen the no treatment plots (5 replications) averaged 1,712 5 kg./ hectare and the plots with 75 kg./P_2O_5 application reached 4,375 kg./hectare. At Patalung the corresponding yields were 600 and 1,822 kg. The difference between the two placements was negligible, and, if any, there was a slight advantage for the surface application, which apparently provided ready access for the roots.

It is evident that much attention has been given to the efficient use of phosphorus. Its use is so important and its implications are so many that it will take some years to develop a body of information that is needed.

The use of fertilizers is only a part of the soil improvement program that offers opportunity. Many soils are low in organic matter, some exceedingly high in acidity. and their preparations often unsatisfactory. It has been shown that many of the present rice varieties are poor, some responding to improved methods of culture better than others. These and many other problems must be given attention in order to make a "Fertilizer Program" effective. There can be no missing links in this chain.

Some 500 widely scattered fertilizer

demonstrations were conducted the last season and twice that number are now under way this year. It seems that Thai farmers are keen to use fertilizers. Of course there are such problems as education on the efficient use of fertilizers, transportation, storage, and credit that have to be solved. Finally the price received by the famers for their rice is much below the world price while fertilizers must be purchased on the world market.

RICE BREEDING IN BRITISH GUIANA

by

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Rice was introduced into British Guiana over a hundred years ago. Indentured labour from India, who came over to work on sugar estates, brought with them seed of the food to which they were accustomed to try and grow it in the new country of their adoption. The new crop adapted itself very successfully and its culture extended over the colony until not only was self-sufficiency attained, but an export trade was developed to the neighbouring West Indian Islands. The Indians also brought with them their traditional methods of cultivation. Land preparation was performed by oxen, transplanting and reaping by hand, the grain was threshed by trampling with oxen, and winnowed in the wind. A natural form of peasant cultivation on small holdings thus developed and persisted through the years to the present day.

Many varieties were introduced from time to time. History records varieties introduced from various States of the U.S.A., but there is little doubt that the main varieties which survived and were grown for commercial production were of Indian origin. These varieties were mainly suitable for hand cultivation; they tillered profusely, lodged heavily, shattered easily, and gave high yields of paddy of good milling quality. By a process of trial and error their maturity-periods of 150-160 days were chosen to fit in with the seasonal pattern. Varieties were grown according to individual preference and were spread around from nieghbour to neighbour, but in the absence of an organized system of pure seed production and distribution, mixtures in the field were the rule rather than the exception.

Rice improvement work was begun in 1902 by the Department of Agriculture, becoming more intensified as the importance of the crop grew. Up to 1932, most of the local varieties had

been collected, classified, and tested. By means of pure line selection, a number of outstanding varieties had been built up and released into commercial production. Introductions from other countries had not been neglected, but they were not successful and failed to displace the local varieties.

At this time it was felt that the full potentialities of pure line selection had been explored, and little further improvement could be expected by this method. Hybridization was then resorted to, and a programme of work commenced, continuing up to the present day. So long as cultivation was carried out on a peasant basis, the objective remained that of varieties suited to hand methods. But with the intervention of World War II critical changes were brought about in the markets which were to affect the breeding policy.

Throughout the history of the rice industry the limiting factors to expansion have been labour supply and water control. The colony had never been able to meet the full demands of the West Indies, which imported its additional requirements from the East, Burma chiefly. (Competitive prices of Burmese rice, which were lower than the local product, no doubt helped to limit local production). World War II cut off the Eastern supplies and British Guiana was called upon to increase its output. This could only be achieved by bringing in new land and introducing mechanised methods of cultivation. Mechanised cultivation of rice had its own attendant problems, and while investigations were started to solve these, it soon became obvions that the varieties hitherto used in hand cultivation were unsuitable for mechanical cultivation. Where lodging and shattering were previously insignificant factors, they now assumed primary importance; tall vegetative growth was a disadvantage for combine harvesting and shorter varieties were preferable; varieties with wider ranges of maturity-periods were required in order to spread the harvest and make more economical use of machinery equipment.

The breeding programme was therefore completely changed, and a different set of objectives aimed at. The ideal varieties desired were to be short, erect, stiff-strawed, resistant to lodging, non-shattering, high-yielding, of good milling quality and with a wide range of maturity-periods.

The initial step was to import breeding material from outside, since none of the characteristics required except high yield and good milling quality existed in the local material. Material was obtained from the U.S.A., Venezuela, Japan, Indonesia, Thailand and other countries. Selection of this material was made easier by use of the FAO genetic catalogues, where characters were described in full detail. Observation of the imported varieties showed that while many of them were adapted to mechanical reaping, their yields were too low for commercial production. Their chief use therefore was as parents for crossing.

Intensive hybridization was com-

menced in 1950. A systematic programme of single crossing and backcrossing was laid down and pursued. In single crossing, several crosses were made between local and introduced parents. In backcrossing, the F_1s were backcrossed to the local parents for transference of characters. In each generation single plant selections are being made, particular attention being paid to the characters sought in order to fix the desired types. With local parents belonging to the *indica* strain and many of the introductions containing *japonica* blood, high sterility was encountered in the F_1 generation of crosses between the two. This was a deterrent to the raising of large F_2 populations and had to be overcome by producing greater quantities of F_1 seed. Sterility, however, has been observed to decrease as the generations advance.

Advantage is being taken of the natural climatic conditions which permit the growing of two crops per annum. The breeding programme is thereby greatly accelerated and hybrids reach homozygosity in half the time compared with regions where only one crop per annum can be grown. The most advanced generation will have reached the F_6 stage in 1953, just three years after making the cross. Fertilizers are used on all breeding plots in order to show up and preserve the ability of response carried by the *japonica* strain.

Observations are being made concerning the behaviour of the characteristics of introduced parents in the various family crosses, and the number of generations during which the various characters keep segregating and responding readily to selection. Wide differences have been noted in the heritability of the same phenotypic characters in different parents. It has not therefore been possible to select the best parents with full confluence on a purely phenitypic basis, and the method of attack has been to use all the introduced parents available and make a large number of crosses with local parents. Since superiority of some characters can be detected at an early stage, discards can be made relatively early and only the best families retained.

The breeding and selection programme is greatly handicapped by the absence of adequate knowledge of the inheritance of characters. A few lines of study in inheritance and character association have been initiated, and it is hoped to expand this work as time and funds permit. Without such studies selection has to be carried on on a purely empirical basis.

The breeding programme is as yet in its early stages. At its commencement little was known of what to expect in the segregating progeny of crosses between such widely different strains. Unexpected behaviour and unforeseen difficulties are continually arising, but they are slowly being elucidated and overcome as knowledge increases. Several breeding lines are being established possessing the desired characteristics; on these lines lie our hopes that the industry will at an early date be supplied with the varieties which it so urgently needs for its future expansion.

LOOKING FORWARD TO THE NEXT MEETING OF THE INTERNATIONAL RICE COMMISSION IN JAPAN IN 1954

C.W. Chang, Executive Secretary

By invitation of the Government of Japan, the Fourth Session of the International Rice Commission, together with the annual meetings of its two Working Parties, will be held in Tokyo in the early part of October 1954. The exact date of these meetings will be announced a little later. October has been chosen because the weather should be fine by that time of the year and the rice crop is about to be harvested in that part of the country.

At the request of the host government, the Executive Secretary recently spent a few weeks in Japan to study the general agricultural situation and to assist the government in making necessary preparation for the next meeting of the International Rice Commission. He was very much impressed by the general agricultural development and, in particular, the rice improvement work. The following is a summary of his observations and impressions. He reported that it is the desire of the host government to have the delegates to the meeting to see as many agricultural organizations, demonstrations and exhibits as possible. He feels sure that the next meeting in Japan is going to be a most interesting one. Look forward to it!

1. The Ministry of Agriculture and Forestry

This is one of the largest Ministries in the Government of Japan, with an annual budget of 7 — 8% of the total amount of national appropriations. It has a new headquarters' building of eight stories recently put up in the centre of Tokyo, with office space for 5,000 people. The Ministry has nine administrative units, namely: Ministers' Secretariat, Agricultural Land Bureau, Agricultural Improvement Bureau, Livestock Bureau, Agricultural Economics Bureau, Raw Silk Bureau, Fisheries Agency, Forestry Agency and Food Agency. Under its direct control, there are 345 regional, prefectural and local offices and agricultural experimental stations, with a total number of 87,000 staff members.

2. A close Coordination between Research and Extension

Both research and extension are administered by the Agricultural Improvement Bureau in the Ministry of Agriculture and Forestry through its two Divisions of Research and Extension. For research work, there are one National Institute of Agricultural Sciences, with its headquarters in Tokyo, and eight Regional Agricultural Experimental Stations, located in different parts of the country. In each of the 46 prefectual governments, there is one Prefectural Agricultural Experimental Station, with one or more branch stations to deal with problems of local nature.

A total number of 4,000 technical people are currently employed for research work, with 3/4 of them in the Ministry

and the rest in the prefectural governments.

Agricultural extension work is the responsibility of the prefectural government, with financial assistance from the National Government. At present for the whole country, there are 700 subject matter specialists, 10,800 farm advisers and 1,000 home advisers. Roughly one farm adviser serves one village of 600 farms. Most of the subject matter specialists are stationed at the perfectural agricultural experimental stations to insure close cooperation and coordination between research and extension.

3. Land Reform and Improvement

By the end of 1950, the land reform was practically completed, involving 30,000,000 pieces of land occupying 2,000,000 hectares or 1/3 of the total land under cultivation in Japan, which was purchased and distributed by the government. Tenant farmers, who own less than 50% of the land they till, now comprise only 12%. They are protected by law and cannot be evicted at will by the land owner.

Japan, with a population of 86 million people, has a land area slightly larger than the British Isles and smaller than the State of California. Furthermore, only 16% of the land in Japan is cultivablable. So Japan is most densely populated.

With the loss of Korea and Formosa, Japan has to import a large amount of food from abroad for home consumption. At present rice is still rationed. In 1951, the net import of rice and other food grains amounted to 3.5 million tons. This means a big drain on the national budget.

The future development of its agricultural production lies in the improvement of the land already under cultivation and the reclamation of the land that can be brought under cultivation if some improvement can be made. It was once estimated that 2,600,000 hectares or 90% of paddy land was in need of physical improvement and that 370,000 hectares of presently single-cropped paddy fields could be made available for double cropping through the improvemet of drainage and irrigation.

After the war, 436,000 hectares of land and 4,000 hectares of sea and marshland have been reclaimed and 743,000 hectares of paddy land improved, with 790,000 hectares more of paddy land now under improvement.

The famous Ryoso Irrigation Project at Sohara, Chiba Prefecture, about a three hour drive from Tokyo, is an interesting one and merits a word of introduction. This project is for both irrigation and drainage purposes in two widely separate areas in the same prefecture. It has two pumping stations. The first one, with 6,000 h.p., which is located at Sohara, pumps water from the Tone River and the nearby low lying land of 1,800 hectares in size and raises it 20.4 meters high and then the water flows through a series of 3 siphons and 20 tunnels and open canals, altogether 7 kilometers long, before it reaches another river, known as Kuri Yama River, which

runs another 24.5 kilometers. At the end of the river, the second pumping station is being installed and it will pump up water 60 ft. high and then the water will flow through a series of tunnels before it reaches another river of 48 kilometers long to irrigate an area of 18,000 hectares of land along the sea coast, about 1/5 of the area under paddy in the whole prefecture. This project was started in 1943 and is expected to be completed in 1958, at an estimated cost of 3,850,000,000 yen, or about 10,000,000 U.S. dollars. It is being planned for the delegates to the meeting of the International Rice Commission in 1954 to see it.

With the assistance of Agricultural Commissions, which are over-all organizations for farmers in the country, small paddy fields in some areas have been consolidated and made over into large ones of regular form, square or oblong, thus making it convenient for cultivation and irrigation.

4. Cooperative Organizations

Cooperative development in Japan is very intensive as well as extensive. In the country there are 133,300 credit cooperatives and 34,130 agricultural cooperative associations, of which 15,072 are for multipurposes. Each association handles a huge volume of business.

Take the Fujimatsu-Kojo Agricultural Cooperative Association in Aichi Prefecture for an illustration. It has 259 members. It markets 100% of rice, 90% of wheat, 70% of other food grains and 100% vegetables, while it purchases 100% of fertilizers and agricultural chemicals, for its members. It operates a big manufacturing plant for the processing of agricultural products such as tomato, asparagus, bamboo shoots, green beans, pears, peaches, mushrooms, soy bean sauce and pickles. A large amount of the finished products is for export. This association has a loud speaker system to keep its members informed of market conditions and as to what kind of agricultural products and how much and when they should be delivered to the plant for processing. The total value of output from the plant in 1952 was 47,000,000 yen, or 130,000 U.S. dollars.

Then there are prefectural and national federations of cooperatives, with banking facilities.

5. Rice Improvement

Rice is the staple food crop in Japan and 39.4% of the total planted area is for rice production. It is cultivated by 83% of all farmers. Its yield is the highest in Asia, ranging from less than two to more than three times higher than the yield of any other country in the region. This high yield is due to a combination of several factors.

In the first place, all paddy fields are irrigated. Water is the limiting factor of crop growth. At present there are 33 state irrigation projects, 300 prefectural projects and 3,800 farmers' association projects, drawing water from different sources of supply, namely: 68.3% from rivers, 18.3% from reservoirs, 1.6% from lakes, 5.3% from wells and 6.5% from other sources.

At the branch station of the National Institute of Agricultural Sciences in Hiratsuka, an interesting experiment on the water requirement of rice crop has been in progress for some years for both paddy fields and upland rice, under controlled conditions. Results of the experiment are being reviewed and will be reported at the next meeting of the International Rice Commission.

The next important factors in the high yield of rice are the use of improved seed and fertilizers and manures. There is in existence a large number of improved rice varieties to be grown under various conditions of the country. Rice growing in Hokkaido became possible only after the cold-resistant and early varieties of rice were produced. Over 70 percent of the area in rice is under improved varieties and about 26 percent of the seed used annually is distributed from the improved varieties. The improved varieties respond well to soil fertility and will grow well only in fertile soil. During the war, when there was a shortage of fertilizer supply, the improved varieties had to be replaced by the ordinary rice seed.

Out of a total of 6,124,000 farm-households, 5,936,000 or 96.6% were reported to use some kind of commercial fertilizers. The standard application of fertilizers including farm supplied manures for paddy per hectare is N 94 kgs., P_2O_5 75 kgs. and K_2O 95 kgs. It has been pointed out that the farmers at present could not use as much fertilizer as they would desire because of the government policy to export some of the fertilizers for dollar earnings.

In general the Japanese farmers are very industrious and know how to cultivate their fields. They treat their fields as vegetable gardens, putting an enormous amount of labour into cultivation. All paddy rice is transplanted.

Because of the smallness of the farms, the average size of which is less than one hectare, the cultivation is done by human labour with or without animal power. But for other farm operations like irrigation and threshing, machinery is extensively used. It has been estimated that 830,000 irrigation machines were in use and 80% of rice threshing was done by machines.

The Japanese Advancement Association of Agricultural Machinery and Implements has agreed to put up an exhibition on the occasion of the International Rice Commission meeting in Tokyo in 1954. This association represents some 300 factories in Japan that manufacture plows, harrows, cultivators, sprayers, threshers, hullers, mills and pumps. Arrangements will be made for demonstrations of the use of most of these implements and machines. One recent development in agricultural machinery is a rice hulling and milling machine, which is a combination of Kyowa rubber roller rice huller and Satahe rice milling units. This machine is a definite improvement over the ones exhibited in Rangoon, Burma, in 1950, when the rice huller and the rice mill were made into separate machines by the two companies.

UTILIZATION OF PHOTOPERIODIC RESPONSE OF SOME RICE VARIETIES FOR INCREASING PRODUCTION IN THE PUNJAB, PAKISTAN

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I. Introduction

The area under rice in Pakistan is 21,036,000 acres, which is 42.5 per cent of the total area under cultivation, and its production is almost double that of all other food-grains put together. Though 90.3 per cent of the rice area is located in East Pakistan and only 3.4 per cent in the Punjab, yet East Pakistan is not self-sufficient and often has to import rice. Apparently increased production in the Punjab can make up the deficit in that part of the country and also ameliorate the economic position of the rice farmers in the Punjab who are generally not well-off due to the single cropping nature of the lands which they cultivate.

While dealing with the effect of transplanting time on the duration of some Punjab rice varieties, Khan, Ahmad and Naqvi (1951) had found that varieties differ in their response to photoperiod. They reported that the varieties, 62 Bara and 337A Begumi, were season-fixed, i.e., came to flower at a particular time of the year irrespective of the time of transplanting, while other varieties like 349 Johna, 370 Basmati, 14 Son, 7 Mushkan, 246 Palman, Sufaid and 278 Sathra were period fixed, i.e., flowered after a more or less specified period, after transplanting. An investigation was undertaken to utilize this knowledge for increasing production per acre by raising a mixed crop of one period-fixed and another season-fixed variety. The trial was made at the Rice Farm, Kala Shah Kaku, during the years 1944 to 1949 and the results of this investigation are summarized in this paper.

II. Material and Method

278 Sathra, an early and period-fixed variety, and 337A Begumi and 62 Bara, two season-fixed late varieties, were utilized in the experiment with the following treatments:

1. 278 Sathra as a pure crop
2. 337A Begumi as a pure crop
3. 62 Bara as a pure crop
4. 278 Sathra and 62 Bara as a mixture in the ratio of 1:2
5. 278 Sathra and 337A as a mixture in the ratio of 1:2

III. Raising of Nurseries

The nursery was sown during the second week of April. For the mixed crop, the seed of 278 Sathra was mixed with either 337A Begumi or 62 Bara, in

the proportion of 1:2 before sowing, the seed rate for the sowing of the nursery being one seer (2 lb.) per marla (=1/160 acre) in all cases. The area sown with the mixed seed was 3 times the area under the pure variety in order to give sufficient seedings for bunch planting. The seedlings were ready for transplanting in the last week of May.

IV. Transplanting

Transplanting was done in a well-puddled field in the end of May every year. While single seedlings were transplanted with 9" x 9" spacing in the case of pure crop, there were 3 seedlings per hill with "6 x 6" spacing in the case of mixed crop. The idea of transplanting the mixture in bunches and at closer spacing was to increase the probability of the seedlings of both varieties coming in each hill. This also helped in overcoming the drawback of greater casualties and less tillering in the season-fixed varieties when grown in mixtures.

It was observed that the period-fixed variety, 278 Sathra, grew at a much faster rate than both of the season-fixed varieties, 62 Bara and 337A Begumi, in both pure and mixed plots. The early variety came to maturity by the end of August, when the late varieties were still growing. In the mixed plots, the early crop was harvested by cutting the tops, taking care that the growing points of the late variety were not injured. The season-fixed varieties continued to grow after this and came to flower in the second week of October as usual. The crop was harvested in the middle of November.

V. Experimental Results

The produce obtained from the various treatments was dried and weighed. The data on the yields are given in the table below. The results of the different treatments may not be strictly comparable due to the variation in spacing and number of seedlings planted per hill and the possible effects of competition but the indications are definite enough.

Average Yields Per Acre in Maunds (1 maund = 82.7 lb.) from Different Treatments during the Years 1944 to 1949.

YEAR	*278 plus 62* / *A*	*278 plus 337A* / *B*	*278* / *C*	*337A* / *D*	*62* / *E*	*Average*
1944	31.45	28.62	27.56	22.14	24.96	26.95
1945	27.46	29.50	25.19	15.53	23.58	24.25
1946	29.34	32.59	26.31	31.83	31.66	30.35
1947	45.22	37.01	37.05	21.45	29.25	33.99
1948	27.79	30.34	16.76	26.87	23.02	24.95
1949	15.21	13.74	17.66	7.87	6.96	12.29
Average	29.41	28.63	25.09	20.95	23.24	

Out of the two mixtures, the mixture with 62 Bara and 278 Sathra gave better yield, but the difference is not significant. The 278 Sathra variety yielded best amongst the pure varieties, but the difference is significant only over 337A Begumi. The highest yield was obtained in 1947 and the increase is significantly greater than that obtained in other years. The lowest yield was obtained in 1949, when the attack of rice stem-borer (Schoenobius sp.) was the greatest and in certain cases, the entire crop was destroyed.

VI. Discussion of Results

The most important rice growing tract of the Punjab, known as "Kalar," comprises parts of the districts of Sheikhupura, Gujranwala and Sialkot. It is irrigated during the summer by inundation canals, which flow from 1st May to 15th October, but according to law, a farmer, who owns 25 acres of land, can grow rice only on $6\frac{1}{4}$ acres or 25% of the land. The rest of the land is allowed to fallow during the crop season. The increase in yield per acre will thus go a long way to better his lot. The experimental results reported here have shown that by growing a mixture of one early maturing period-fixed, and another late maturing season-fixed variety, the yield per acre can be increased by 25.68%. A little extra cost has, however, to be incurred in growing a larger area of nursery for the mixed crop and its lifting and transplanting later on.

INCREASING RICE PRODUCTION IN BRITISH TERRITORIES

The extensive steps taken in British territories towards easing food supplies are set out in "Colonial Territories 1952/3", a report of the Colonial Office recently published in London. This records that no undue difficulties were experienced in carrying out general plans for increasing food production, though rice presented an excep ion. In this case growing populations continue to threaten to outstrip expanding rice production. The problem of ensuring adequate supplies is, however, so important that Her Majesty's Government have requested the colonial governments to examine the possibility of increasing production in their different territories.

Malaya, it is hoped, will be able to increase its own output during the current year by 3%. In North Borneo drainage and irrigation work has already been carried out, and the installation of additional of pumping machinery in Sarawak has made it possible to improve and extend areas under cultivation.

Rice production is gaining momentum outside the Far East at a rate which should ease demands on importers. British Guiana increased its output by about 5,000 tons of milled rice. As a result

the country's surplus was sufficient to supply all the rice required under contract with certain other West Indian colonies. The newly formed Rice Development Corporation is now undertaking the introduction of improved methods of rice farming and milling. Three government rice growing schemes are to be expanded. At the same time the first part of the Torani canal scheme is nearing completion. Work has already started on another large scheme which is to be completed within five years and will bring about 22,000 acres of new rice land into cultivation.

Rice growing is being steadily advanced in Africa. An area of 25,000 acres was tractor ploughed during the year, and experiments started in northern Nigeria to assess the increased yield which could be obtained by the application of fertilisers. Two irrigation schemes covering another 3,000 acres were put into operatien and it is now planned to establish a rice research station. An important investigation is to be carried out to prove whether mangrove swamps can be converted into rice producing areas. Two plots have been set up for this purpose.

The question of mechanising rice growing is being tested in Gambia. Increased production, however, is already being achieved through the construction of causeways to riverine swamps, which up to now were inaccessible. During the coming year it is hoped that 2-3 thousand acres of new rice land will come under production in this way.

Sierra Leone reports 2,000 acres of grassland swamp cleared during the year under a government scheme for mechanised rice cultivation. This scheme alone has increased the average size of family rice holding from $1\frac{1}{2}$ to $8\frac{1}{2}$ acres, and yields per acre have been increased by some 50% over those obtained by traditional methods. Rice growing acreage is to be doubled during the 1953 season.

Mechanised cultivation is being tested in Tanganyika to discover the rice growing potentialities of this country. A local authority is already operating a mechanical cultivation scheme extending over 500 acres. Meanwhile the rice experimental station has been extended and legislation passed setting up a milling board to improve the processing of rice.

Although Northern Rhodesia last year produced only some 2,000 bags of milled rice it is estimated that in five years time output here will have reached 10,000 bags. Surveys of swamp areas are being carried out and agricultural centres have been established with rice as one of the main crops.

WORLD RICE TRADE*

Total exportable supplies of rice in 1953 in the world's surplus countries are estimated at about 4 per cent larger than in 1952.

Export supplies from Burma are considerably larger than last year, while in Thailand the carry-over stocks plus the 1952—53 crop will permit the exportation of a larger volume than last year.

Heavy surpluses will again be available for export from the United States. Exports also are expected to be available from Italy, Ecuador, Spain, Madagascar, Iran, Iraq, Argentina and Uruguay. Because of small crops, however, it is expected that the rice will not be exported from Egypt and Brazil in 1953.

It was reported that international trade in rice in 1952 continued at about the same level as in 1951. Total exports, including re-exports, came to 11,050 million pounds in terms of milled rice, compared with 11,075 million pounds in 1951, the postwar high, and the annual average of 20,000 million pounds in the prewar (1936/40) period.

A feature of the 1952 world rice trade was the increase in the number of countries coming into the market as exporters. The increase occurred in most areas of the world outside of Asia, and is expected to continue in 1953.

Nevertheless, 68 per cent of the world's exports were still from countries in Asia, and four fifths of these, or nearly 60 per cent of the world total were from the "rice bowl"—Thailand, Burma and the Indochinese peninsula.

These three areas exported a total of 6,750 million pounds of rice in 1952, compared with 6,950 million pounds in 1951. Though exports increased in Burma, they declined in Thailand and the Indochina area.

Burma's exported 2,923 million pounds, compared with 2,793 million in 1951. Thailand exported 3,148 million pounds, compared with 3,427 in 1951. Indochinese exports came to 497,000 pounds compared with 725,000 in 1951.

Burma's exports were 45 per cent of its prewar average, while Indochina's were only 15 per cent of its prewar average. Thailand's exports were 8 percent higher than its prewar average.

The reduction in 1952 exports from the surplus countries of Asia was offset by a sharp increase in shipments from North America, as well as by export gains from countries in Europe and South America. Rice exports from Africa, primarily Egypt, were well below those of 1951, and Australia also exported less rice than in 1951

And Portugal for the first time exported a significant amount of rice.

Imports of rice into the deficit countries of Asia increased substantially over 1951. Japan, with imports of 2,197 million pounds, again was the world's largest rice importer, followed by Indonesia, with 1,674 million pounds; India, with 1,618 million pounds; and Malaya, with 1,162 million pounds.

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